CAMECA IMS-1280 PB/PB DATING OF BADDELEYITE IN LAP 02224. A. Zhang[1], W. Hsu[1,2], X. Li[3], Q. Li[3], Y. Liu[3], G. Tang[3], and Y. Jiang[1]. [1]Purple Mountain Observatory, Nanjing 210008, China (aczhang@pmo.ac.cn); [2]Faculty of Earth Sciences, China University of Geosciences, Wuhan 430074, China; [3]Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 100029, China.

Introduction: Pricise dating for lunar rocks is crucial to understand formation and evolution histories of the lunar crust. Most Apollo samples and lunar meteorites had experinced a long history of shock metamorphism. Their isotopic systems could be disturbed. Shock recovery experiments were performed to understand effect of shock metamorphism on baddeleyite age (e.g., [1, 2]). It was found that up to 57 GPa the U-Pb isotopic system was not disturbed. Here, we report badeleyite Pb/Pb dating result in the lunar mare basalt meteorite LaPaz Icefield (LAP) 02224 and discussed its implication for geochronology.

Sample and analytical methods: LAP 02224 is a low-Ti mare basalt found in Antarctica. It is paired with LAP 02205, 02226, 02436, and 03632 [3]. A number of chronological studies have been carried out on these lunar meteorites (e.g., [4-6]). LAP 02224 baddeleyite Pb/Pb dating was performed using the Cameca IMS-1280 at the Institute of Geology and Geophysics of CAS, China following the procedure of [7]. A multicollector mode with four electron multipliers was used to simultaneously measure secondary ion beam intensities of ^{204}Pb, ^{206}Pb, ^{207}Pb, and $^{90}Zr_2{}^{16}O_2$. Relative yield of each electron multiplier was calibrated with a Phalaborwa baddeleyite standard [8]. Correction of common Pb was made by measuring ^{204}Pb, assuming a common lead composition of $^{206}Pb/^{204}Pb = 14 \pm 4$ and $^{207}Pb/^{206}Pb = 0.84 \pm 0.2$. Only data with $^{206}Pb/^{204}Pb$ >1000 are accepted. Raman spectra of baddeleyite were acquired using the Renishaw RM2000 Raman spectrometer at Nanjing University.

Results and discussion: Two baddeleyite grains in LAP 02224 were analyzed (**Table 1**). One grain (**Fig. 1a**, 6 × 20 μm) shows a large internal variation of Pb/Pb age, ranging from 3109 ± 29 Ma to 3547 ± 21 Ma (2σ). The ages are well correlated with the brightness on the cathodoluminescence (CL) image (**Fig. 1b**). The bright CL area has an older Pb/Pb age than the dark CL area. Four analyses on the other grain yield identical results within analytical errors (**Fig. 2a**), and the weighted mean Pb/Pb age is 3005 ± 10 Ma (2σ) (**Fig. 2b**). The Raman spectra of both baddeleyite grains show strong and sharp peaks at 1090, 1145, 1220, and 1270 cm^{-1} (**Fig. 3**). A few peaks with low intensity occur in 200–600 cm^{-1} and their Raman shifts are the same. The Raman features indicate that these two baddeleyite grains were not vitrified.

Table 1. SIMS baddeleyite Pb/Pb data

Sample spot #	$\frac{^{206}Pb}{^{204}Pb_m}$	±1σ (%)	$\frac{^{207}Pb}{^{206}Pb_c}$	±1σ (%)	$t_{207/206}$ (Ma)	±2σ
Baddeleyite grain-1						
lap1@1	5742	22	0.2437	0.67	3160	21
lap1@2	4770	26	0.2359	0.92	3109	29
lap1@3	4706	17	0.2433	0.59	3157	19
lap1@4	2381	13	0.2686	0.61	3297	19
lap1@5	1515	17	0.3152	0.69	3547	21
Baddeleyite grain-2						
lap2@1	1986	10	0.2232	0.61	3020	19
lap2@2	2673	11	0.2220	0.55	3011	18
lap2@3	3234	17	0.2212	0.84	3005	27
lap2@4	3912	15	0.2184	0.58	2985	18

$^{206}Pb/^{204}Pb_m$ is the measured value. $^{207}Pb/^{206}Pb_c$ is the calculated value after common-lead correction, assuming a common Pb composition of $^{206}Pb/^{204}Pb = 14 \pm 4$, $^{207}Pb/^{206}Pb = 0.84 \pm 0.2$.

The variation of Pb/Pb age within a baddeleyite grain indicates that the U-Pb system of LAP 02224 was disturbed by later thermal events. On the Moon, shock effect is the major metamorphic process that could disturb the U-Pb system in minerals. Thus, it is very likely that this variation could be due to a severe shock event after crystallization of LAP 02224. Such a process could also cause local recrystallization of baddeleyite (c.f., [9]). The distribution of trace elements (e.g., Ti, **Fig. 1c**) in the baddeleyite seems to support this suggestion. Our observation is conflict with the results of shock recovery experiments in which U-Pb and Pb/Pb ages were not affected by shock metamorphism [1,2]. The difference between natural shock effect and shock recovery experiments could be due to their different HP/HT duration [10]. Natural shock metamorphism usually has a long duration (up to seconds); whereas the duration of HP/HT in shock recovery experiments is at the level of micro second.

The younger age of baddeleyite in LAP 02224 is generally compatible with previous results (~3Ga: Rb-Sr, Ar/Ar, and phosphate U-Pb ages; 3.15 ± 0.02 Ga: Sm-Nd age) [4-6]. This work demonstrates that the crystallization age of LAP lunar meteorites is much

older (≥3.55 Ga) than the whole rock ages which could record the time of a later shock event at ~3 to 3.1 Ga.

References: [1] Niihara T. et al. (2009) *LPS XXXX,* abstract 1562. [2] Niihara T. et al. (2009) *Meteoritic & Planetary Sci.* 44, A157. [3] Day J. M. D. et al. (2006) *GCA*, 70, 1581–1600. [4] Nyquist L. E. et al. (2005) *LPS XXXVI*, abstract 1374. [5] Anand M. et al. (2006) *GCA*, 70, 246–264. [6] Fernandes V. A. et al. (2009) *MAPS*, 44, 805–821. [7] Li X. H. et al. (2009) *G-cubed*, 10. Q04010. [8] Heaman L. M. (2009) *Chemical Geology*, 261, 43–52. [9] Pidgeon R. T. et al. (2007) *GCA*, 71, 1370–1381. [10] Sharp T. M. and De Carli P. S. (2006) *MESS II*, 653–677.

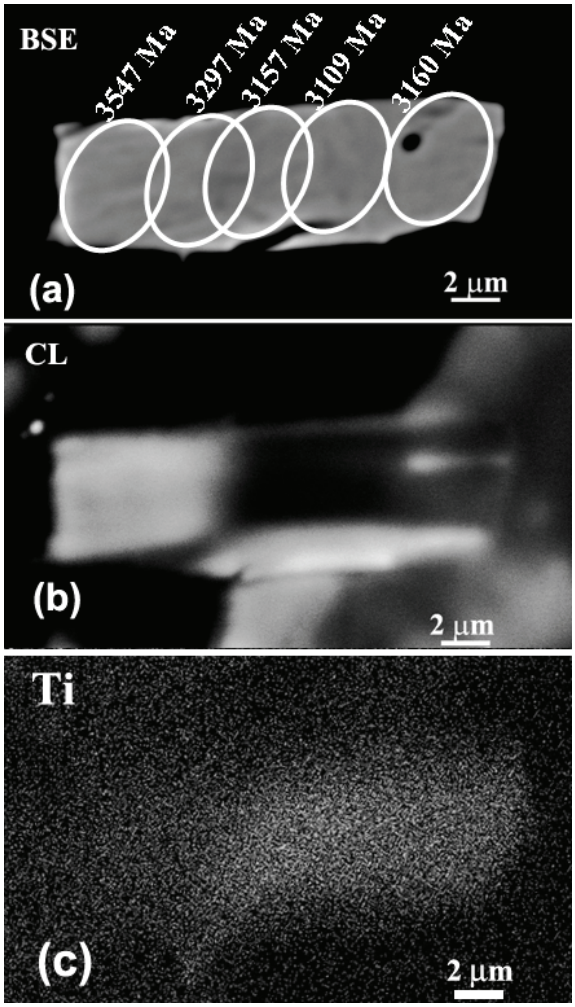

Figure 1. (a) Back-scattered electron (BSE), (b) Cathodoluminescence (CL) image, and (c) X-ray Ti distribution of a baddeleyite grain in LAP 02224. The ellipsoidal circles in the BSE image are the SIMS spots. Bright areas in the CL image are older than dark areas.

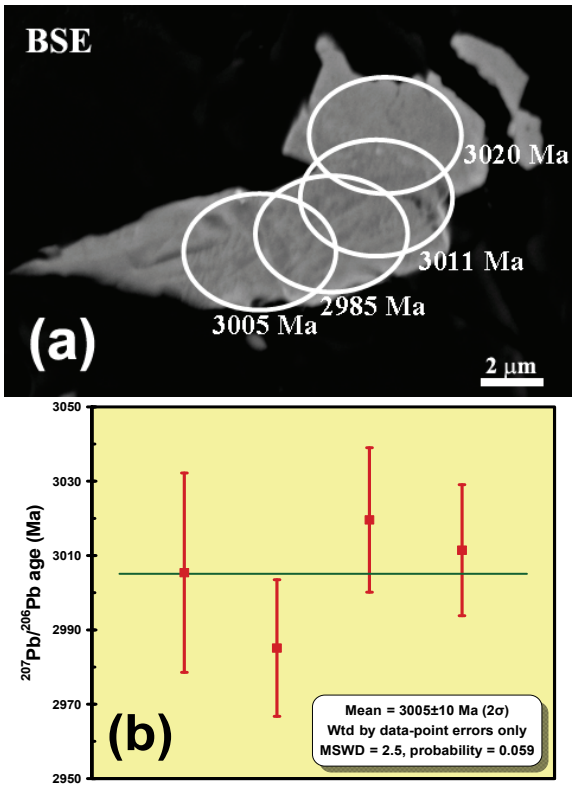

Figure 2. (a) Back-scattered electron image and (b) weighted mean $^{207}Pb/^{206}Pb$ age of a baddeleyite grain in LAP 02224. The ellipsoidal circles are the SIMS spots.

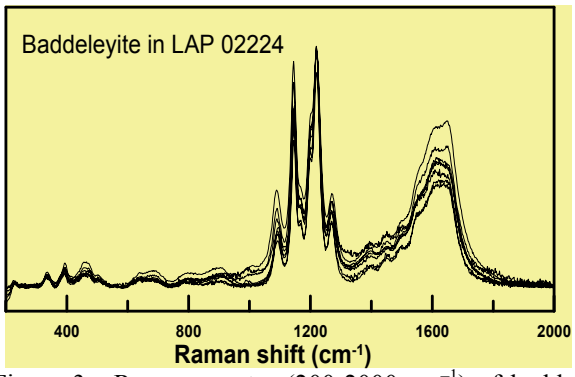

Figure 3. Raman spectra (200-2000 cm^{-1}) of baddeleyite in LAP 02224.

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